



Full wwPDB NMR Structure Validation Report ⓘ

Feb 13, 2017 – 01:09 am GMT

PDB ID : 2MMG
Title : Structural Characterization of the Mengovirus Leader Protein Bound to Ran GTPase by Nuclear Magnetic Resonance
Authors : Bacot-Davis, V.R.; Palmenberg, A.C.; Cornilescu, C.C.; Markley, J.L.
Deposited on : 2014-03-15

This is a Full wwPDB NMR Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<http://wwpdb.org/validation/2016/NMRValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

Cyrange : Kirchner and Güntert (2011)
NmrClust : Kelley et al. (1996)
MolProbity : 4.02b-467
Percentile statistics : 20161228.v01 (using entries in the PDB archive December 28th 2016)
RCI : v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV : Wang et al. (2010)
ShiftChecker : trunk28760
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : recalc28949

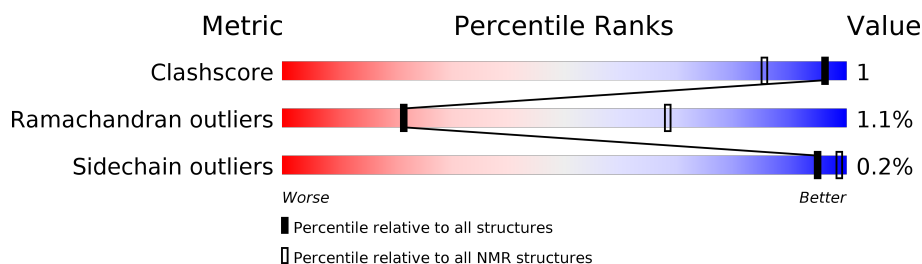
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR

The overall completeness of chemical shifts assignment is 83%.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	NMR archive (#Entries)
Clashscore	125131	11601
Ramachandran outliers	121729	10391
Sidechain outliers	121581	10367

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and a grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	216	82% . 14%

2 Ensemble composition and analysis

This entry contains 10 models. Model 6 is the overall representative, medoid model (most similar to other models). The authors have identified model 1 as representative, based on the following criterion: *lowest energy*.

The following residues are included in the computation of the global validation metrics.

Well-defined (core) protein residues			
Well-defined core	Residue range (total)	Backbone RMSD (Å)	Medoid model
1	A:9-A:175 (167)	0.13	6
2	A:182-A:190 (9)	0.56	9
3	A:199-A:207 (9)	0.09	2

Ill-defined regions of proteins are excluded from the global statistics.

Ligands and non-protein polymers are included in the analysis.

The models can be grouped into 3 clusters and 2 single-model clusters were found.

Cluster number	Models
1	7, 8, 9
2	2, 6, 10
3	1, 4
Single-model clusters	3; 5

3 Entry composition [i](#)

There is only 1 type of molecule in this entry. The entry contains 3449 atoms, of which 1725 are hydrogens and 0 are deuteriums.

- Molecule 1 is a protein called GTP-binding nuclear protein Ran.

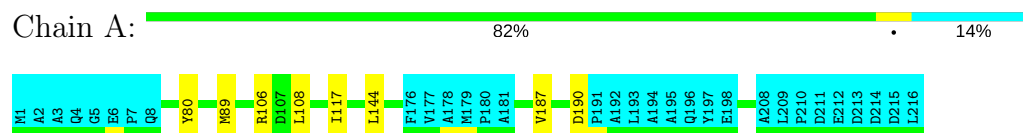
Mol	Chain	Residues	Atoms						Trace
1	A	216	Total	C	H	N	O	S	0
			3449	1109	1725	295	313	7	

4 Residue-property plots

4.1 Average score per residue in the NMR ensemble

These plots are provided for all protein, RNA and DNA chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. Stretches of 2 or more consecutive residues without any outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

- Molecule 1: GTP-binding nuclear protein Ran

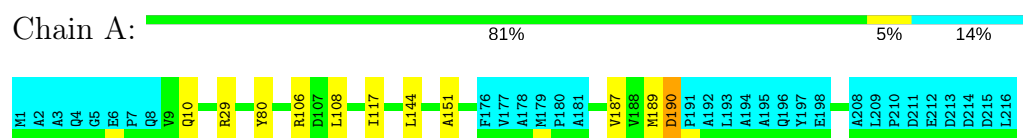


4.2 Scores per residue for each member of the ensemble

Colouring as in section 4.1 above.

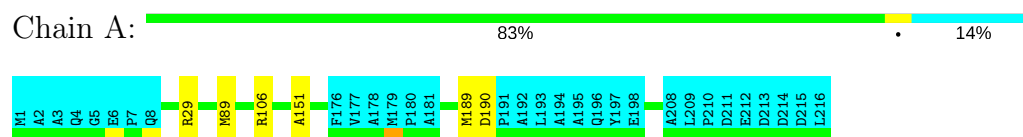
4.2.1 Score per residue for model 1

- Molecule 1: GTP-binding nuclear protein Ran



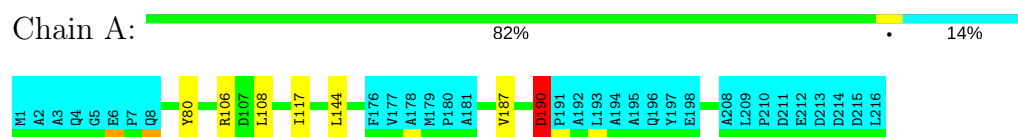
4.2.2 Score per residue for model 2

- Molecule 1: GTP-binding nuclear protein Ran



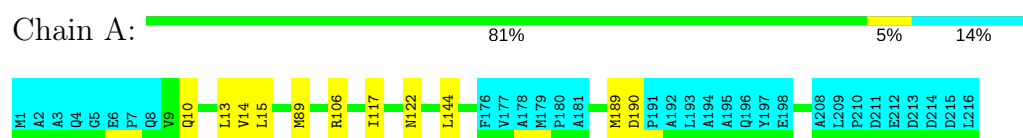
4.2.3 Score per residue for model 3

- Molecule 1: GTP-binding nuclear protein Ran



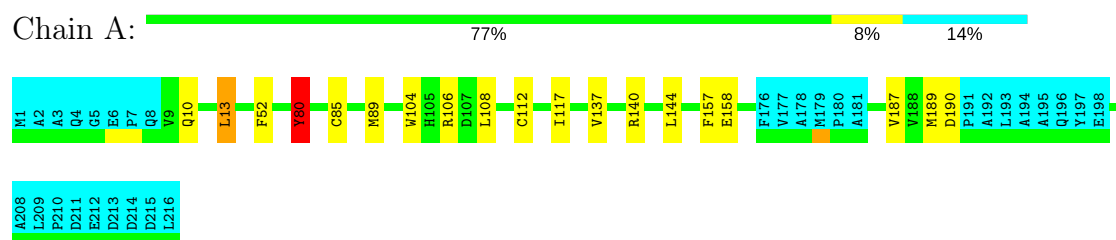
4.2.4 Score per residue for model 4

- Molecule 1: GTP-binding nuclear protein Ran



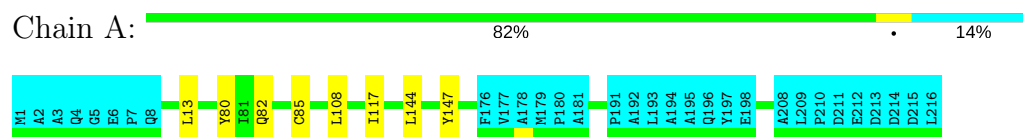
4.2.5 Score per residue for model 5

- Molecule 1: GTP-binding nuclear protein Ran



4.2.6 Score per residue for model 6 (medoid)

- Molecule 1: GTP-binding nuclear protein Ran



4.2.7 Score per residue for model 7

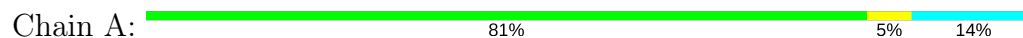
- Molecule 1: GTP-binding nuclear protein Ran





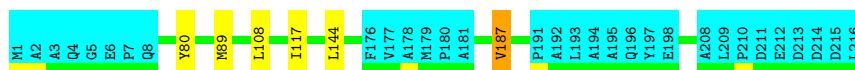
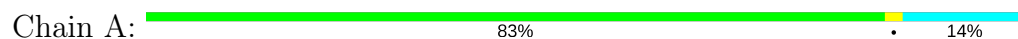
4.2.8 Score per residue for model 8

- Molecule 1: GTP-binding nuclear protein Ran



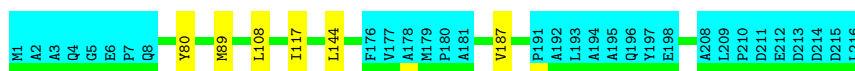
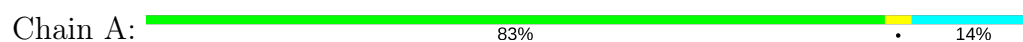
4.2.9 Score per residue for model 9

- Molecule 1: GTP-binding nuclear protein Ran



4.2.10 Score per residue for model 10

- Molecule 1: GTP-binding nuclear protein Ran



5 Refinement protocol and experimental data overview

The models were refined using the following method: *torsion angle dynamics*.

Of the 50 calculated structures, 10 were deposited, based on the following criterion: *structures with the lowest energy*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
CYANA	structure solution	
TALOS	geometry optimization	
SPARTA+	geometry optimization	
CYANA	refinement	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	2mmg_cs.str
Number of chemical shift lists	1
Total number of shifts	2631
Number of shifts mapped to atoms	2631
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	83%

No validations of the models with respect to experimental NMR restraints is performed at this time.

6 Model quality i

6.1 Standard geometry i

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the (average) root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	#Z>5	RMSZ	#Z>5
1	A	0.78±0.01	0±0/1532 (0.0±0.0%)	1.09±0.02	1±2/2076 (0.0±0.1%)
All	All	0.78	0/15320 (0.0%)	1.09	10/20760 (0.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	Chirality	Planarity
1	A	0.0±0.0	0.9±0.9
All	All	0	9

There are no bond-length outliers.

All unique angle outliers are listed below. They are sorted according to the Z-score of the worst occurrence in the ensemble.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)	Models	
								Worst	Total
1	A	13	LEU	CB-CA-C	-6.43	97.99	110.20	5	1
1	A	60	LYS	N-CA-CB	5.82	121.07	110.60	8	1
1	A	190	ASP	N-CA-CB	5.57	120.62	110.60	1	1
1	A	158	GLU	CB-CA-C	-5.54	99.33	110.40	5	1
1	A	52	PHE	N-CA-CB	5.16	119.89	110.60	5	1
1	A	10	GLN	N-CA-CB	5.16	119.88	110.60	5	1
1	A	190	ASP	N-CA-C	5.11	124.79	111.00	3	1
1	A	147	TYR	N-CA-CB	5.09	119.76	110.60	6	1
1	A	157	PHE	N-CA-CB	5.04	119.67	110.60	5	1
1	A	80	TYR	CB-CG-CD1	-5.04	117.98	121.00	5	1

There are no chirality outliers.

All unique planar outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Group	Models (Total)
1	A	89	MET	Mainchain	5
1	A	189	MET	Mainchain	3
1	A	80	TYR	Sidechain	1

6.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in each chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	1495	1516	1516	3±1
All	All	14950	15160	15160	29

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 1.

All unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:13:LEU:HD22	1:A:85:CYS:SG	0.74	2.23	5	1
1:A:29:ARG:HH21	1:A:151:ALA:HA	0.55	1.61	1	2
1:A:117:ILE:HB	1:A:144:LEU:HD22	0.51	1.82	5	9
1:A:80:TYR:CE1	1:A:108:LEU:HG	0.48	2.43	3	7
1:A:104:TRP:O	1:A:108:LEU:HD13	0.47	2.09	5	1
1:A:13:LEU:HD23	1:A:14:VAL:N	0.47	2.24	4	1
1:A:80:TYR:HD1	1:A:112:CYS:HG	0.44	1.54	5	1
1:A:13:LEU:HD22	1:A:15:LEU:CD1	0.44	2.43	4	1
1:A:89:MET:HB3	1:A:122:ASN:HD21	0.42	1.74	4	1
1:A:13:LEU:CD2	1:A:85:CYS:HB2	0.41	2.45	6	1
1:A:137:VAL:HG12	1:A:140:ARG:HH21	0.41	1.76	5	1
1:A:13:LEU:HD22	1:A:15:LEU:HD12	0.41	1.92	4	1
1:A:21:THR:HG22	1:A:122:ASN:HD21	0.41	1.74	7	1
1:A:158:GLU:HA	1:A:161:PHE:CE2	0.40	2.51	7	1

6.3 Torsion angles

6.3.1 Protein backbone

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all PDB entries followed by that with respect to all NMR

entries. The Analysed column shows the number of residues for which the backbone conformation was analysed and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	185/216 (86%)	181±1 (98±1%)	2±1 (1±0%)	2±1 (1±1%)	21	68
All	All	1850/2160 (86%)	1809 (98%)	21 (1%)	20 (1%)	21	68

All 4 unique Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	187	VAL	7
1	A	190	ASP	6
1	A	106	ARG	6
1	A	189	MET	1

6.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all PDB entries followed by that with respect to all NMR entries. The Analysed column shows the number of residues for which the sidechain conformation was analysed and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	163/185 (88%)	163±0 (100±0%)	0±0 (0±0%)	95	99
All	All	1630/1850 (88%)	1627 (100%)	3 (0%)	95	99

All 2 unique residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	77	ASP	2
1	A	82	GLN	1

6.3.3 RNA ⓘ

There are no RNA molecules in this entry.

6.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

6.5 Carbohydrates [i](#)

There are no carbohydrates in this entry.

6.6 Ligand geometry [i](#)

There are no ligands in this entry.

6.7 Other polymers [i](#)

There are no such molecules in this entry.

6.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

7 Chemical shift validation

The completeness of assignment taking into account all chemical shift lists is 83% for the well-defined parts and 82% for the entire structure.

7.1 Chemical shift list 1

File name: 2mmg_cs.str

Chemical shift list name: *assigned_chem_shift_list_1*

7.1.1 Bookkeeping

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	2631
Number of shifts mapped to atoms	2631
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	72

7.1.2 Chemical shift referencing

The following table shows the suggested chemical shift referencing corrections.

Nucleus	# values	Correction \pm precision, ppm	Suggested action
$^{13}\text{C}_\alpha$	212	-1.33 ± 0.20	Should be applied
$^{13}\text{C}_\beta$	196	-0.40 ± 0.19	None needed (< 0.5 ppm)
$^{13}\text{C}'$	211	-0.48 ± 0.18	None needed (< 0.5 ppm)
^{15}N	215	0.65 ± 0.32	Should be applied

7.1.3 Completeness of resonance assignments

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 83%, i.e. 1964 atoms were assigned a chemical shift out of a possible 2372. 36 out of 36 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	^1H	^{13}C	^{15}N
Backbone	727/909 (80%)	189/362 (52%)	362/370 (98%)	176/177 (99%)
Sidechain	1007/1233 (82%)	648/720 (90%)	298/452 (66%)	61/61 (100%)

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	Total	¹H	¹³C	¹⁵N
Aromatic	230/230 (100%)	120/120 (100%)	95/95 (100%)	15/15 (100%)
Overall	1964/2372 (83%)	957/1202 (80%)	755/917 (82%)	252/253 (100%)

The following table shows the completeness of the chemical shift assignments for the full structure. The overall completeness is 82%, i.e. 2235 atoms were assigned a chemical shift out of a possible 2710. 40 out of 40 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

	Total	¹H	¹³C	¹⁵N
Backbone	842/1056 (80%)	216/420 (51%)	423/432 (98%)	203/204 (100%)
Sidechain	1146/1407 (81%)	744/822 (91%)	338/521 (65%)	64/64 (100%)
Aromatic	247/247 (100%)	129/129 (100%)	103/103 (100%)	15/15 (100%)
Overall	2235/2710 (82%)	1089/1371 (79%)	864/1056 (82%)	282/283 (100%)

7.1.4 Statistically unusual chemical shifts ⓘ

The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	114	ASN	ND2	1114.29	124.24 – 101.34	437.3
1	A	104	TRP	CE3	174.81	129.06 – 111.96	31.8
1	A	104	TRP	CD2	155.17	134.55 – 120.45	19.6
1	A	127	LYS	HB3	6.92	3.10 – 0.40	19.1
1	A	84	GLN	HB3	6.96	3.37 – 0.67	18.3
1	A	127	LYS	HD3	5.66	2.75 – 0.45	17.7
1	A	127	LYS	HD2	5.61	2.76 – 0.46	17.4
1	A	127	LYS	HG2	5.43	2.67 – 0.07	15.6
1	A	127	LYS	HE3	5.80	3.86 – 1.96	15.2
1	A	127	LYS	HG3	5.58	2.76 – -0.04	15.1
1	A	140	ARG	NE	108.39	92.63 – 76.73	14.9
1	A	127	LYS	HE2	5.73	3.87 – 1.97	14.8
1	A	127	LYS	HB2	5.20	3.03 – 0.53	13.7
1	A	134	LYS	CB	54.58	41.68 – 23.88	12.2
1	A	82	GLN	NE2	132.38	120.91 – 102.81	11.3
1	A	183	ALA	HB1	4.16	2.61 – 0.11	11.2
1	A	183	ALA	HB2	4.16	2.61 – 0.11	11.2
1	A	183	ALA	HB3	4.16	2.61 – 0.11	11.2
1	A	36	GLU	CB	48.14	38.65 – 21.35	10.5
1	A	85	CYS	HB3	7.56	5.25 – 0.55	9.9
1	A	139	HIS	HB3	6.88	5.00 – 1.10	9.8
1	A	85	CYS	HB2	7.31	5.20 – 0.70	9.7

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Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	139	HIS	HB2	6.46	4.91 – 1.31	9.3
1	A	84	GLN	NE2	128.39	120.91 – 102.81	9.1
1	A	205	GLN	NE2	128.39	120.91 – 102.81	9.1
1	A	175	GLU	CA	76.25	67.86 – 46.86	9.0
1	A	45	VAL	CB	17.10	41.76 – 23.66	-8.6
1	A	68	GLY	C	189.53	183.33 – 164.53	8.3
1	A	28	LYS	NZ	59.20	49.86 – 18.16	7.9
1	A	186	GLU	CD	198.61	192.68 – 172.48	7.9
1	A	151	ALA	C	160.74	188.57 – 166.97	-7.9
1	A	60	LYS	CA	74.29	67.97 – 45.97	7.9
1	A	84	GLN	HB2	4.01	3.30 – 0.80	7.9
1	A	32	THR	CG2	29.98	27.15 – 15.95	7.5
1	A	99	LYS	CE	47.85	46.00 – 37.80	7.3
1	A	143	ASN	ND2	129.29	124.24 – 101.34	7.2
1	A	44	GLY	CA	54.58	51.81 – 38.91	7.1
1	A	158	GLU	CA	72.15	67.86 – 46.86	7.0
1	A	23	LYS	CE	47.55	46.00 – 37.80	6.9
1	A	82	GLN	CD	170.41	186.62 – 172.72	-6.7
1	A	29	ARG	CA	72.15	68.35 – 45.25	6.6
1	A	33	GLY	C	161.91	183.33 – 164.53	-6.4
1	A	62	ASN	ND2	98.29	124.24 – 101.34	-6.3
1	A	127	LYS	CE	46.97	46.00 – 37.80	6.2
1	A	123	LYS	NZ	53.49	49.86 – 18.16	6.1
1	A	99	LYS	HE2	4.08	3.87 – 1.97	6.1
1	A	94	SER	C	163.97	183.48 – 165.88	-6.1
1	A	99	LYS	NZ	53.30	49.86 – 18.16	6.1
1	A	23	LYS	NZ	53.30	49.86 – 18.16	6.1
1	A	127	LYS	NZ	53.29	49.86 – 18.16	6.1
1	A	170	GLY	C	162.50	183.33 – 164.53	-6.1
1	A	37	LYS	NZ	53.20	49.86 – 18.16	6.1
1	A	119	LEU	CA	42.87	66.36 – 44.96	-6.0
1	A	124	VAL	CG1	29.68	28.40 – 14.60	5.9
1	A	110	ARG	NE	94.02	92.63 – 76.73	5.9
1	A	38	LYS	NZ	52.40	49.86 – 18.16	5.8
1	A	22	GLY	C	184.81	183.33 – 164.53	5.8
1	A	84	GLN	HG3	3.94	3.75 – 0.85	5.7
1	A	99	LYS	HE3	3.98	3.86 – 1.96	5.7
1	A	113	GLU	CA	69.22	67.86 – 46.86	5.6
1	A	104	TRP	CD1	137.30	136.18 – 116.78	5.6
1	A	165	ALA	C	165.72	188.57 – 166.97	-5.6
1	A	89	MET	CE	27.93	26.97 – 7.37	5.5
1	A	124	VAL	CB	42.57	41.76 – 23.66	5.4

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Mol	Chain	Res	Type	Atom	Shift, ppm	Expected range, ppm	Z-score
1	A	154	ASN	ND2	125.21	124.24 – 101.34	5.4
1	A	76	ARG	NE	93.29	92.63 – 76.73	5.4
1	A	29	ARG	NE	93.29	92.63 – 76.73	5.4
1	A	213	ASP	CB	49.61	49.06 – 32.66	5.3
1	A	99	LYS	CD	34.95	34.86 – 23.06	5.1
1	A	60	LYS	NZ	49.99	49.86 – 18.16	5.0
1	A	194	ALA	C	166.90	188.57 – 166.97	-5.0
1	A	12	LYS	NZ	49.89	49.86 – 18.16	5.0

7.1.5 Random Coil Index (RCI) plots [i](#)

The image below reports *random coil index* values for the protein chains in the structure. The height of each bar gives a probability of a given residue to be disordered, as predicted from the available chemical shifts and the amino acid sequence. A value above 0.2 is an indication of significant predicted disorder. The colour of the bar shows whether the residue is in the well-defined core (black) or in the ill-defined residue ranges (cyan), as described in section 2 on ensemble composition.

Random coil index (RCI) for chain A:

